**3GPP TSG RAN WG1 #103-e R1-2009715**

**e-Meeting, October 26th – November 13th, 2020**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#4 for multi-beam enhancement

**Document for:** Discussion and Decision

1. Introduction

Picking up from where the group left off in the moderator summaries R1-2009499 and R1-2009574, the 1st GTW session, the 1st and 2nd check-points, below are the summaries and moderator proposals.

1. Summary

We will focus on some of the moderator proposals not included in the agreements from the first and second check-points and the UL parameters.

* 1. Issue 1 (unified TCI framework)

The discussion of UL parameters was not concluded due to lack of inputs. This time, we aim at reaching some conclusion.

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| Action: Interested companies are encouraged to provide their preferences in below and, if any, their reasoning in  Goal: Select one of the three alternatives and, after that, formulate a proposal for endorsement |

Table 1 Additional inputs: for round-4 discussion: UL parameters

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| **Issue** | **Companies’ views** |
| Additional parameters included in or concurrent with (but not included in) unified TCI   * **Alt1**. Include as a part of unified TCI framework (as a part of the UL spatial reference in TCI state definition) * **Alt2**. Include concurrently with but outside unified TCI framework (linked by RRC configuration) * **Alt3**. Not include | **UL PC parameters (P0/alpha, CL index)**   * **Alt1**: LG * **Alt2**: Apple, OPPO * **Alt3**:   **PL RS**   * **Alt1**: OPPO, LG * **Alt2**: * **Alt3**: Apple |

Table 2 Additional inputs (if any) for round-4 discussion: UL parameters

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| **Company** | **Input** |
| Apple | Our views are provided in the table.  We think the DL RS for beam indication can be used as PL-RS, this can help to reduce the possibility of mismatch between UL Tx beam and DL Rx beam for PL measurement. |
| OPPO | Our views for each aspect are provided in the table. |
| LG | For additional parameters, UL timing parameter should be considered that each UE panel can be associated to same or different TRP. Especially for the different TRP, large difference of propagation delay to each TRP is quite critical. Not only for mTRP cases, inter-panel delay should also be taken into account that the timing difference between panels can be increased depending on the geometry of the panels and implementation error/calibration for panel. |
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* 1. Issue 3 (beam indication signaling medium)

“for joint beam indication” text

**Agreement**

On beam indication signaling medium to support joint or separate DL/UL beam indication in Rel.17 unified TCI framework:

* Support L1-based beam indication using at least UE-specific (unicast) DCI to indicate joint or separate DL/UL beam indication from the active TCI states
  + The existing DCI formats 1\_1 and 1\_2 are reused for joint beam indication
    - FFS: If additional DCI format(s) are supported, e.g. existing DCI formats 0\_0, 0\_1, 0\_2, 1\_0 as well as new DCI format(s) dedicated for beam indication

The part of the agreed text was “(for) beam indication” (‘joint’ was in red since it was suggested and discussed but without conclusion, therefore the word ‘joint’ is not yet agreed). During the discussion several versions were proposed:

1. V1. “for joint and separate DL/UL beam indication”: This is equivalent to “for beam indication” since the unified TCI framework comprises joint and separate DL/UL.
2. V2. “for joint DL/UL beam indication”: This keeps the separate DL/UL mode open. The rationale is that DCI 1\_1/1\_2 only includes DL assignment (but not UL grant). In this case, UL-only beam indication (used when, e.g. MPE event occurs) can only be done when DL assignment is available thereby resulting in poor latency performance.
3. V3. (reworded) “for joint DL/UL beam indication, as well as DL-only beam indication in case of separate DL/UL beam indication”: This keeps only the UL part for separate DL/UL mode open. The rationale is the same as V2 and there is no reason not to use DCI 1\_1/1\_2 for DL-only beam indication.

**Observation 1**: Companies’ preferences can be summarized as follows (along with the primary arguments made by some of the proponents). Since V2 is supported by only 1 company who also supports V3, it is removed (see [1] for details).

* V1 (“for joint and separate DL/UL beam indication”):
  + Supported by (14): Apple, OPPO, NTT Docomo, LG, Spreadtrum, Nokia/NSB, Huawei/HiSi, Ericsson, Intel, Fraunhofer IIS/HHI, vivo
  + Main arguments (so far):
    - Against V3 with dedicated DCI (previous UL Tx beam) it’s unclear why NW schedule such transmission given the MPE event. Against V3 with UL DCI, it’s unclear the NW would know if the UE received the DCI or not, given that there is no ACK for UL DCI
* V3 (“for joint DL/UL beam indication, as well as DL-only beam indication in case of separate DL/UL beam indication”):
  + Supported by (16): Qualcomm, CATT, ZTE, NTT Docomo, Xiaomi, MediaTek, APT, Samsung, Futurewei, Fraunhofer IIS/HHI, IDC, Lenovo/MoM, Sony, AT&T
  + Main arguments (so far):
    - For V3 with UL DCI, the time point(s) of separate DL and UL beam indication may be different with high probability. Utilizing UL DCIs for UL scheduling seems reasonable.
    - Against V1, UL-only beam indication (note: perhaps used *only* when MPE event occurs) can only be done when DL assignment is available thereby resulting in poor latency performance and restriction

It is apparent that there is no consensus in changing the text of the agreement (to either V1 or V3). Therefore, the agreed text remains as “The existing DCI formats 1\_1 and 1\_2 are reused for beam indication”. This implies that DCI formats 1\_1 and 1\_2 can be used for both joint DL/UL and separate DL/UL TCI state update (beam indication).

**Observation 2:** In terms of TCI state update (beam indication) signaling and ACK mechanism:

* The use of DCI format 1\_1 and 1\_2 for joint DL/UL and DL-only (in case of separate DL/UL) TCI state update (beam indication) is quite clear.
* However, the use of DCI format 1\_1 and 1\_2 for UL-only (in case of separate DL/UL) TCI state update (beam indication) needs more clarification – at least to address the drawbacks pointed out by the proponents of V3 (note: the ACK mechanism is clear, but how to respond to MPE event in a timely manner without dependence on DL assignment is unclear)

**Observation 3**: Those supporting V3 essentially proposes the support of a new DCI for UL TCI update (UL beam indication), which can potentially be used for DL TCI update (DL beam indication) – either with joint or separate DL/UL beam indication:

* Regardless whether this is a “brand new” format or based on an existing format (such as 1\_0, 0\_0, 0\_1, or 0\_2), this constitutes a dedicated DCI format for beam indication since the following will have to be introduced: 1) TCI field(s), 2) an acknowledgment mechanism.
* Likewise, the points raised by the proponents of V1 against V3 (especially by Huawei) need to be addressed in the dedicated DCI format design

In light of the above observation, the following proposal is made:

**Proposal 3.A**: In RAN1#104-e, on the Rel.17 L1-based TCI state update (beam indication) for the unified TCI framework, interested companies are to provide the following:

* How to use/extend DCI formats 1\_1 and 1\_2 for UL-only (in case of separate DL/UL) TCI state update (beam indication), e.g.
  + How to respond to MPE event in a timely manner without dependence on DL assignment
* (In a best effort manner) decide whether to support at least one additional DCI format dedicated for UL-only beam indication (in case of separate DL/UL), including:
  + Whether the format can also be used for DL-only beam indication (in case of separate DL/UL) and joint DL/UL beam indication
  + Whether it is a “brand new” format or based on existing DCI formats other than 1\_1 and 1\_2 (e.g. 1\_0, 0\_0, 0\_1, or 0\_2)
  + Acknowledgment mechanism
  + How to respond to MPE event in a timely manner

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| Action: Interested companies are encouraged to provide their inputs on Proposal 3.A  Goal: Arrive at an agreeable (potential) revision of Proposal 3.A |

Table 3 Additional inputs for round-4 discussion: Joint beam indication proposal 3.A

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| **Company** | **Input** |
| Apple | We think it can be handled by MAC CE design. Similar to multi-TRP design, in MAC CE, gNB can configure the indication for each TCI codepoint in DCI. To support separate UL beam indication, gNB can configure one TCI-codepoint to map with 1 UL TCI.  The MAC CE can configure the indication of each TCI codepoint in DCI to provide flexibility for all kinds of functionalities. |
| OPPO | Using DCI 1\_1 and 1\_2 to indicate UL TCI state can be supported by mapping UL TCI state to TCI codepoint in the DCI format.  However, we prefer to support a dedicated DCI format with small payload size for TCI state indication, which can support both joint and separate TCI state update. |
| LG | Support FL proposal in general. Regarding MPE, we think that MPE-related reporting mechanism from UE should be clarified firstly. |
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UE capability for latency

**(Initial) Proposal 3.B**: On Rel.17 DCI-based beam indication:

* Regarding application time of the beam indication: if beam indication is received, down-select from the following:
  + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication
  + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication
  + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y
* FFS: When and how to apply the minimum beam indication delay
* Support a UE capability for the minimum value of X or Y
  + FFS: the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability
  + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE
  + FFS: Whether to support more than one values of X/Y and UE capabilities for the minimum values of X/Y
  + FFS: whether existing UE capability (e.g. beamSwitchTime) can be reused as this UE capability.
* The latency of the DCI design (with or without specification impact) should be significantly improved with respect to the utilization of MAC CE

Only the blue highlighted text was still in flux during the discussion.

Based on the inputs below, Proposal 3.B is modified below as a starting point for GTW discussion (especially the bracketed texts):

**Revised Proposal 3.B**: On Rel.17 DCI-based beam indication:

* Regarding application time of the beam indication: if beam indication is received, down-select from the following:
  + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication
  + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication
* FFS: When and how to apply the minimum beam indication delay
* [FFS:] Support a UE capability for the minimum value of X or Y
  + [FFS:] the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability
  + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE
* FFS: whether existing UE capability (e.g. beamSwitchTime, TimeDuration for QCL) can be reused as this UE capability
* Criterion for selecting application time of the beam indication:
  + [The latency of the DCI design (with or without specification impact) should be significantly improved with respect to the utilization of MAC CE]
  + [RAN1 strives to reduce the latency of DCI design with respect to the utilization of MAC CE]
  + [It is expected that the latency of a DCI-based TCI state update is significantly improved with respect to the latency of a MAC CE-based TCI state update]

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| Action: Interested companies are encouraged to provide their inputs on the revised Proposal 3.B.  Goal: Arrive at an agreeable formulation of the revised Proposal 3.B |

Table 4 Additional inputs for round-4 discussion: UE capability of proposal 3.B

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| **Company** | **Input** |
| Qualcomm | Suggest to remove 1st FFS or merge it into 3rd FFS, since 1st FFS seems similar to the 3rd FFS  Suggest to remove 2nd FFS, since UE capability may not make too much sense if there is only a single candidate value. In this case, the spec may simply define a fixed value |
| Apple | Support |
| ZTE | Firstly, we may need to consider using DCI signaling of indicating the applicable time offset, e.g., as for PDSCH reception. Then, besides *beamSwitchTime*, *timeDurationForQCL* that is applied for PDSCH beam switching in R15/R16 should be considered. Please find our update in red.  **Proposal 3.B**: On Rel.17 DCI-based beam indication:   * Regarding application time of the beam indication: if beam indication is received, down-select from the following:   + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication   + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication   + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y * FFS: When and how to apply the minimum beam indication delay * Support a UE capability for the minimum value of X or Y   + FFS: the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling or DCI command based the UE capability   + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE   + FFS: Whether to support more than one values of X/Y and UE capabilities for the minimum values of X/Y   + FFS: whether existing UE capability (e.g. beamSwitchTime, timeDurationForQCL) can be reused as this UE capability. * The latency of the DCI design (with or without specification impact) should be significantly improved with respect to the utilization of MAC CE |
| OPPO | Re the 1st FFS:  The existing timing defined for DCI-based PDSCH/AP CSI-RS beam indication is to consider the DCI decoding latency and then determine the default TCI state. A big difference in the new DCI-based TCI indication is a ACK for the DCI would be defined. And the action of applying the new TCI state is after that ACK. So a new timing line will be needed. Thus, the first FFS sub-bullet is not needed.   * + ~~FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y~~   Re the 2nd and 3rd FFS: we support to FFS.  We do not support the “or DCI command” added by ZTE.  Re the last bullet:  the latency of one beam switch would be impacted by multiple factors, including how fast the UE can track the beam, whether the indicated TCI state is known or known and the control signaling used for beam indication. We would have to improve from all those aspects to minimize the latency. Using DCI is one step to reduce the latency of beam operation from the perspective of control signaling. Evaluations have shown that DCI-based beam indication has advantage over MAC CE based method in terms of both latency and signaling overhead. That is one of the reason for the agreement we made for issue 3 previously. And the UE capability of beam update latency will be discussed and specified anyway for this new feature. Thus the added text seems not necessary. |
| NTT Docomo | Support FL proposal. |
| LG | Support FL’s proposal in general while we are still on the fence to agree something for UE capability for latency, which is unclear as we mentioned in e-mail reflector last week. |
| Xiaomi | Support FL proposal |
| MediaTek | Support current proposal.  @Qualcomm, on 2nd FFS, we agree that the number of candidate values supported by UE should be more than one. However, the exact X/Y value should be decided and configured by gNB, and there might be one value for both DL/UL beam indications, or two values, one for DL and one for UL. Thus, we think current wording is fine.  @ZTE, we don’t support the “or DCI command” added by ZTE due to no clear motivation. The value of X/Y shall be decided and semi-statically configured to Ues based on UE capability reports.  @OPPO, since the application time is not decided, it may be Alt 1 (the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication). If so, some companies think existing timing can be reused. |
| Spreadtrum | Support to keep these FFSs before making further decisions. |
| Nokia/NSN | Regarding   * + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y   to recover from the error case that either PDCCH or HARQ-ACK is lost, there should be UE provided minimum beam switching latency from the HARQ-Ack but also network configured and provided overall beam switching latency that is equal to or greater than UE’s provided value.  Regarding   * + FFS: Whether to support more than one values of X/Y and UE capabilities for the minimum values of X/Y   The better procedure here is to agree first what are the possible values of X/Y, the capability definition would follow from that. The current proposal seems to suggest first that there would be multiple values defined, and only then RAN1 will discuss the possible values, and that is reverting the logic of the process.  Regarding   * The latency of the DCI design (with or without specification impact) should be significantly improved with respect to the utilization of MAC CE   we support the requirement since otherwise the feature would be useless.  We have the following proposal   * FFS: When and how to apply the minimum beam indication delay * FFS: Support a UE capability for the minimum value of X or Y   + FFS: the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability   + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE   + FFS: Whether to support more than one values of X/Y and UE capabilities for the minimum values of X/Y   + FFS: whether existing UE capability (e.g. beamSwitchTime) can be reused as this UE capability. |
| APT | We support FL proposal. |
| Huawei, HiSilicon | Regarding Alt1: Given that we agreed to reuse ACK for scheduled PDSCH as that for DCI, we don’t understand the intention of listing Alt1 here, which may leave the PDCCH beam indication unprotected.  Regarding the last bullet: We are not sure about the exactly meaning of ‘significantly improved’ and prefer to avoid such vague statement. As captured in previous bullets, the application timing and UE capability will be discussed anyway. |
| Ericsson | We have strong concerns of   * + FFS: the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability   The beam application time must be determined by the gNB. This cannot be FFS.  The first FFS seems superfluous –Alt1 and Alt2 seems to span the possibilities  The second FFS is unclear: a UE capability is associated with a set of candidate values – as always. What does the second FFS add to that??  It is unclear what the latest highlighted paragraph means: it sounds like a relevant design target, but what do we really agree to? Do we agree on that the minimum UE capability must be smaller than 0.5ms?  Comment to Huawei: for Alt1, the corresponding application time need to be extended to give time for the ACK. |
| Samsung | Support FL proposal with following updates  The first FFS: Out understanding is that DCI is only used for TCI not spatial relation in R15/R16. We suggest that we can reword as:   * + FFS: whether any existing UE capability ~~timing~~ defined for time of DCI based TCI/~~spatial relation~~ update can be used/updated for X/Y   For second FFS “FFS: Whether to support more than one value …” Is this for the same UE or across Ues. If it is for the same UE what is the rationale for that? If it is for different Ues, then it is natural to have more than one capability to distinguish Ues. In either case, this FFS can be removed  Is there a difference between the last FFS of the first bullet and the last FFS of the third bullet? We think that these two can be merged.  The last bullet is a design target rather than a proposal for DCI design. Maybe we can reword to a note along the lines of …  Note: It is expected that the latency of a DCI-based TCI state update is significantly improved with respect to the latency of a MAC CE-based TCI state update. |
| FUTUREWEI | It is better to discuss UE capability later after designs are clearer. |
| Fraunhofer | Support FL proposal |
| InterDigital | We are fine with Moderator’s proposal |
| vivo | Supportive of the first FFS |
| Lenovo/MoM | We suggest to remove the first FFS so we can down select between Alt1 and Alt 2.  Regarding the 2nd and 3rd FFS, we think it can be discussed in UE capability. |
| Sony | Support the FL proposal in principle.  Regarding the last bullet (listed as below), would it be better to say “RAN1 strives to reduce the latency of DCI design with respect to the utilization of MAC CE”?   * The latency of the DCI design (with or without specification impact) should be significantly improved with respect to the utilization of MAC CE   Moreover, it seems vague to measure whether the latency performance can be “significant” improved. |
| **After revision** | |
| Apple | We do not quite understand why some companies have concern for the UE capability. There are 3 options to define the action delay:   * Option 1: a predefined value * Option 2: a UE capability * Option 3: unspecified – up to UE implementation   Option 1 often leads to the worst case and prohibits UE to have an opportunity to do a better job. We are also ok for option 3. But option 2 is our typical way. |
| OPPO | We do not support to put UE capability with FFS. Naturally, the minimum time shall be a UE capability. If no UE capability is defined and we specify a predefined value in the spec, then we will have to choose a very large value to accommodate the worst scenario, which would be even worse for this feature. |
| LG | We suggest to add the following FFS back.   * + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y   As commented in email, DCI to PDSCH timing and PDSCH to HARQ-ACK timing is already well defined in Rel-15/16, so we cannot agree on the first bullet without having the FFS above. |
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* 1. Issue 6 (beam refinement/tracking)

**(Initial) Proposal 6.A**: Investigate and, if needed, specify the following enhancements for beam refinement/tracking in Rel.17:

* Group 1: Beam measurement and reporting enhancement ~~via RACH~~ (e.g. MAC CE based beam reporting, RO for measurement and MSG3 for reporting)
* Group 2: Improving efficiency (latency and/or overhead) of beam refinement assuming the unified TCI framework (issue 1), for example:
  + Enabling joint DL TX and RX beam refinement/tracking (P2+P3)
  + Additional UE report to aid P1/P2/P3 related measurement/report configuration (triggering frequency or periodicity)
* Group 3: Beam management with reduced DL signaling assuming the unified TCI framework (issue 1), for example:
  + Dynamic beam update based on beam report (without beam indication)
  + Dynamic beam measurement and report triggered by beam indication (without CSI-RS/CSI triggering)
  + Configuring/indicating to UE multiple SSBs for beam tracking
  + Semi-static/pre-planned (RRC based) beam transition (for, e.g. isolated HST deployment)
  + Reducing activation delay of TCI states (e.g. via storing QCL properties of a subset of source RSs for a time period)
* The scope of investigation (including down selection or combining) will be within and/or across the three groups. Consider the dependence on issue 1 and 3 (including their maturity) for the specification work on issue 6, if any

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| Action: Interested companies are encouraged to provide their inputs on Proposal 6.A  Goal: Arrive at an agreeable formulation of Proposal 6.A |

Table 5 Additional inputs for round-4 discussion: proposal 6.A

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| **Company** | **Input** |
| Intel | We do not agree that this proposal should be lower priority compared to other proposals in this WI. Based on agreed simulation assumptions, we have provided evaluations in [R1-2008977](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2008977.zip) which show that gains from proposals covered in this section are much larger than many of the other features being discussed. Therefore, we don’t see why the proposals in this section cannot be discussed concurrently with other issues. Additionally, we do not think Group 1 needs to be discussed in MIMO since some aspects can be covered in Coverage Enhancement. Proposals in Group 2 and Group 3 should be discussed further. |
| Huawei/HiSi | Without removing Group 1 and establishing certain prioritization, we still prefer not to agree on Proposal 6.A in this meeting |
| AT&T | we do not agree to the prioritization at this meeting, or to remove group 1 from the discussion at this point. We believe that the FL proposal is a reasonable compromise to investigate and if needed specify enhancements for beam refinement and tracking in Rel. 17, taking into account the maturity of issues 1 and 3 |
| LG | On the last bullet, add: In addition, consider overlapping of scope with other WI/SI, e.g. coverage enhancement (CE). |
| Samsung | Regarding proposal 6.A, we support this proposal. To improve the efficiency (lower latency and lower overhead) of beam management we need to look at both beam refinement/tracking as well as beam indication. Beam indication is well covered by items 1 and 3. Item 6 covers improvements to beam refinement/tracking, which is the second leg to facilitate more efficient UL/DL beam management. We support all 3 groups of proposal 6.A, we think that they should all be investigated.    As a compromise, we can accept Jaehoon’s proposal to make the list of groups 2 and 3 as examples. However, we think that this investigation should be part of FeMIMO and not part of any other WI/SI given its strong relevance to MIMO |
| Apple | We think beam measurement and report should be a good aspect, but we think it is better not to restrict it for RACH. We think our focus should be more for connected mode UE (remove RACH, add AMC CE based reporting) |
| OPPO | Overall, the scope in this proposal is too wide. Down-scoping is needed for reasonable workload. Please note we need to work other 5 big issues in this agenda that are supposed to be with higher priority than Issue 6. From our perspective, the following three items in this proposal have high priority for study, which could benefit the beam tracking:     * + Enabling joint DL TX and RX beam refinement/tracking (P2+P3)   + Additional UE report to aid P1/P2/P3 related measurement/report configuration (triggering frequency or periodicity)   + Dynamic beam measurement and report triggered by beam indication (without CSI-RS/CSI triggering) |
| LG | As suggested via email, we think that it is needed to add the following text:  **In addition, consider overlapping of scope with other WI/SI, e.g. coverage enhancement (CE).** |
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# References

1. R1-2009574 Moderator summary#3 for multi-beam enhancement Moderator (Samsung)
2. R1-2009499 Moderator summary#2 for multi-beam enhancement Moderator (Samsung)
3. R1-2008147 Moderator summary#1 for multi-beam enhancement Moderator (Samsung)